

*Revised 1/11/81
with draft* WHAT IS CLAIMED IS:

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1. A scanning unit for moving an object to be moved along at least one axis, comprising:
a first actuator for moving the object along a first axis, the first actuator having a pair of end portions, the object being attached to one of the end portions, the first actuator being held at a position in the vicinity of the center in dimension or the center of gravity thereof.

10 2. The scanning unit according to claim 1, wherein the first actuator comprises a stacked piezoelectric actuator which is extendable along the first axis.

3. The scanning unit according to claim 1, wherein the first actuator comprises a pair of stacked piezoelectric actuators and a connection member for connecting the stacked piezoelectric actuators in series, and the connection member is held.

15 4. The scanning unit according to claim 1, further comprising a second actuator for moving the object along a second axis different from the first axis.

20 5. The scanning unit according to claim 4, wherein the second actuator comprises a stacked piezoelectric actuator which is extendable along the second axis.

6. The scanning unit according to claim 4, wherein the second actuator has a pair of end portions, one of the end portions being connected with the first actuator and the other one of the end portion being

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7. The scanning unit according to claim 4, wherein the second actuator is held at a position in the vicinity of the center in dimension or the center of gravity thereof.

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8. The scanning unit according to claim 7, wherein the second actuator has a pair of end portions, and one of the end portions is brought into contact with a part close to an end portion of the first actuator to which the object is attached.

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9. The scanning unit according to claim 4, further comprising a third actuator for moving the object along a third axis different from both the first axis and the second axis.

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10. The scanning unit according to claim 9, wherein the second actuator comprises a stacked piezoelectric actuator which is extendable along the second axis, and the third actuator comprises a stacked piezoelectric actuator which is extendable along the third axis.

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11. The scanning unit according to claim 9, wherein the second actuator has a pair of end portions, one of the end portions being connected to the first actuator, the other one of the end portions being fixed, the third actuator having a pair of end portions, one of the end portions being connected to the first actuator, the other end of the end portions being fixed.

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12. The scanning unit according to claim 9,
wherein the second actuator is held at a position in
the vicinity of the center in dimension or the center
of gravity thereof and the third actuator is held at a
position in the vicinity of the center in dimension or
the center of gravity thereof.

13. The scanning unit according to claim 12,
wherein the second actuator has a pair of end portions,
one of the end portions being brought into contact with
a portion close to an end portion of the first actuator
to which the object is attached, the third actuator
having a pair of end portions, one of the end portions
being brought into contact with a portion close to the
end of the first actuator to which the object is
attached.

14. The scanning unit according to claim 9,
wherein the second actuator and the third actuator
comprises a common cylindrical piezoelectric actuator.

15. The scanning unit according to claim 1,
20 further comprising: a movable member for holding the
first actuator; a second actuator for moving the
movable member along a second axis different from the
first axis; and a first guide mechanism for restricting
movement of the movable member along the first axis.

25 16. The scanning unit according to claim 15,
wherein the second actuator comprises a pair of stacked
piezoelectric actuators which are extendable along the

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second axis, and each of the stacked piezoelectric actuators has a pair of end portions, one of the end portions being connected to the movable member, the other one of the end portions being fixed.

5 17. The scanning unit according to claim 16, wherein the first guide mechanism has a pair of elastic members provided on both sides of a movable plate along the second axis.

10 18. The scanning unit according to claim 15, further comprising: a third actuator for moving the movable member along a third axis different from both the first axis and the second axis; and a second guide mechanism for restricting movement of the movable member along the first axis.

15 19. The scanning unit according to claim 18, wherein the second actuator comprises a pair of stacked piezoelectric actuators which are extendable along the second axis, each of the stacked piezoelectric actuators having a pair of end portions, one of the end portions being connected to the movable member, the other one of the end portions being fixed, the third actuator comprises a pair of stacked piezoelectric actuators which are extendable along the third axis, each of the stacked piezoelectric actuators having a pair of end portions, one of the end portions being connected to the movable member, the other one of the end portions being fixed.

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5 20. The scanning unit according to claim 19,
wherein the first guide mechanism having a pair of
elastic members provided on both sides of the movable
plate along the second axis and the second guide
mechanism has a pair of elastic members provided on
both sides of the movable plate along the third axis.

10 21. The scanning unit according to claim 20,
wherein the end portion of the stacked piezoelectric
actuator of the second actuator is connected to the
movable member through a third elastic member, and the
end portion of the stacked piezoelectric actuator of
the third actuator is connected to the movable member
through a second elastic member.

15 22. The scanning unit according to claim 21,
wherein the elastic members of the first guide
mechanism have relatively high rigidity along the third
axis but relatively low rigidity along the second axis
and, on the contrary, the elastic members of the second
guide mechanism have relatively high rigidity along the
20 second axis but relatively low rigidity along the third
axis.

25 23. The scanning unit according to claim 22,
wherein the elastic member of the first guide mechanism
includes a rectangular spring having an elongated slit
extending along the third axis and the elastic member
of the second guide mechanism includes a rectangular
spring having an elongated slit extending along the

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second axis.

24. The scanning unit according to claim 9,
further comprising a movable member which supports the
second actuator and is supported by the third actuator,
5 the second actuator having a pair of end portions, one
of the end portions being connected to the first
actuator, the other one of the end portions being
connected to the movable member, the third actuator
having a pair of end portions, one of the end portions
10 being connected to the movable member, the other one of
the end portions being fixed.

25. The scanning unit according to claim 24,
wherein the first actuator comprises a pair of stacked
piezoelectric actuators and a connection member for
15 connecting the stacked piezoelectric actuators in
series.

26. The scanning unit according to claim 25,
wherein the second actuator comprises a stacked
piezoelectric actuator which is extendable along the
20 second axis, and the third actuator comprises a stacked
piezoelectric actuator which is extendable along the
third axis.

27. The scanning unit according to claim 25,
further comprising a first guide mechanism for
25 restricting movement of the movable member along the
first axis.

28. The scanning unit according to claim 27,

wherein the first guide mechanism includes an elastic hinge mechanism.

29. The scanning unit according to claim 28,
wherein the elastic hinge mechanism includes a pair of
5 elastic members provided on both sides of the movable
member along the second axis.

30. The scanning unit according to claim 27,
wherein the first guide mechanism includes a minute
ball rolling guide.

10 31. The scanning unit according to claim 30,
wherein the minute ball rolling guide includes a base
plate positioned under the movable member, a plurality
of minute balls arranged between the base plate and the
movable member, a pressing plate arranged above the
15 movable member, a plurality of minute balls arranged
between the pressing plate and the movable member, and
a plurality of screws for pressing the pressing plate
against the base plate through the movable member and
the minute balls.

20 32. The scanning unit according to claim 27,
further comprising a second guide mechanism for
restricting movement of the connection member of the
first actuator along the first axis.

25 33. The scanning unit according to claim 32,
wherein the second guide mechanism includes a minute
ball rolling guide.

34. The scanning unit according to claim 33, wherein

the minute ball rolling guide includes a plurality of minute balls arranged between the movable member and the connection member, a pressing plate arranged above the connection member, a plurality of minute balls arranged between the pressing plate and the connection member, and a plurality of screws for pressing the pressing plate against the movable member through the connection member and the minute balls.

35. A scanning microscope for using a probe to observe a surface of a sample, comprising:

10 a probe arranged in the vicinity of a surface of a sample;

15 a cantilever for supporting the probe;

 a scanning unit for relatively scanning the probe and the sample; and

20 a displacement detection system for detecting displacement of the cantilever based on the interaction of the probe and the sample,

 the scanning unit including:

25 a first actuator for moving an object to be moved which is either the probe or the sample along a first axis, the first actuator having a pair of end portions, the object being attached to one of the end portions, the first actuator being held at a position in the vicinity of the center in dimension or the center of gravity thereof;

 a second actuator for moving the object along a

second axis different from the first axis; and
a third actuator for moving the object along a
third axis different from both the first axis and the
second axis,

5 the second actuator and the third actuator
comprising a common cylindrical piezoelectric actuator.

36. A scanning microscope for using a probe to
observe a surface of a sample, comprising:

10 a probe arranged in the vicinity of a surface of a
sample;

 a cantilever for supporting the probe;
 a scanning unit for relatively scanning the probe
and the sample; and

15 a displacement detection system for detecting
displacement of the cantilever based on the interaction
of the probe and the sample,

 the scanning unit including:

20 a first actuator for moving an object to be moved
which is either the probe or the sample along a first
axis, the first actuator having a pair of end portions,
the object being attached to one of the end portions,
the first actuator being held at a position in the
vicinity of the center in dimension or the center of
gravity thereof;

25 a movable member for holding the first actuator;

 a second actuator for moving the movable member
along a second axis different from the first axis;

a third actuator for moving the movable member along a third axis different from both the first axis and the second axis; and

5 a guide mechanism for restricting movement of the movable member along the first axis.

37. A scanning microscope for using a probe to observe a surface of a sample, comprising:

a probe arranged in the vicinity of a surface of a sample;

10 a cantilever for supporting the probe;

a scanning unit for relatively scanning the probe and the sample; and

15 a displacement detection system for detecting displacement of the cantilever based on the interaction of the probe and the sample,

the scanning unit including:

20 a first actuator for moving an object to be moved which is either the probe or the sample along a first axis, the first actuator having a pair of end portions, the object being attached to one of the end portions, the first actuator being held at a position in the vicinity of the center in dimension or the center of gravity thereof;

25 a second actuator for moving the object along a second axis different from the first axis, the second actuator having a pair of end portions, one of the end portions being connected to the first actuator;

a movable member for supporting the second actuator;

a third actuator for moving the object along a third axis different from both the first axis and the 5 second axis, the third actuator having a pair of end portions, one of the end portions being connected to a movable member to support the movable member, the other one of the end portions being fixed; and

10 a guide mechanism for restricting movement of the movable member along the first axis.

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